CEDTECH International Journal of Environmental Science & Biotechnology
Volume 3, Number 1, March 2022
http://www.cedtechjournals.org
ISSN: 2756-4541

ENVIRONMENTAL EFFECT OF HEAVY METAL CONTENT IN SOIL: GUZELYURT DUMPING SITE, NORTH CYPRUS

Rabiu Mahmoud Musa, Muhammad Abubakar Sa'id
Department of Geography, Federal University of Lafia, Nasarawa State, Nigeria
Department of Chemistry, Federal University of Lafia, Nasarawa State, Nigeria
Email:rabiu.mahmoud@gmail.com

ABSTRACT

The soil distribution of heavy metals concentration caused by industrial solid wastes deposited in an open dumping site, the area receives approximately large amount of solid waste from the industrial and municipal solid waste materials. Soil samples were collected from the study area and analyzed at the laboratory from forty five (45) different sampling points, heavy metals content in the sample is detected and presented by mass concentration in mg/kg, the results indicate the heavy metals content in the soil such as Zn, Cu, Pb, and Cd were all detected by using the X-ray fluorescence (XRF) spectrometer machine, the ratio of these selected heavy metals accumulation in the soil are shows in the following orders of results as Zn range from 33.7mg/kg–1397.96mg/kg, Cu range from 11.18mg/kg–472.9mg/kg, Pb range from 4.6mg/kg–375mg/kg and Cd range from 0–162.8mg/kg in only one soil samples, the ratio shows that Zn>Cu>Pb>Cd in the soil. Contamination by solid waste disposal generally pollutes soil, plants and other micro and macro organisms feed or grazed in the area and pollutes immediate environment, also human health and other living organisms is at risks if the system of wastes disposal is not rectified at open dumping site.

Keyword: *Dumping Site, Environment, Heavy Metals, Soil, and Solid Waste.*

INTRODUCTION

The waste generation occurs in virtually all human activities, such as agriculture, industries, and domestic affairs. Managing waste in society has been a challenge for as long as people have gathered together in sufficient numbers. Waste has imposed a stress on local resources (Strange, 2002). Solid waste is generated from residential, commercial, industrial, institutional, construction and demolition process and Municipal services (Rechel et al, 2009). A mixture of these constituents of solid waste are fine dust, metal, glass, paper, cardboard, textiles, putrescible vegetable materials, plastics, rice husk, tyres, cans, etc. (Abd'razack et al., 2013).According to Agbu, (2013) wastes are environmentally unfriendly for the ecosystem and suggested two reasons; It causes the release of toxic substances to the air such as dioxin and furans a cancer inducing compound is released into the atmosphere, other ozone depleting and greenhouse gases, Waste when left unattended for long time constitute some serious health hazards causes offensive odor, pollute underground water source and decrease environmental aesthetic and quality. A harmful substance has negative effects on the natural environment, human health and agricultural production efficiency. Toxic chemical substances introduced into the environment may be transported either by air, water and living organisms and may become a part of the natural biogeochemical cycle and accumulate in the food chain (Gadzała-Kopciuch, 2004).Consequences of industrial waste become visible, it is often too late to prevent them and chronic toxic effects, impossible to notice at the initial stage of the process, may manifest after many years (Alloway and Ayres, 1998). Effects on the organisms are manifest when this regulation mechanism breaks down as a result of either deficiency or toxicity metal (Duffus, 2002).Solid wastes are organic and inorganic wastes generated by rapidly increasing production, consumption and other human and animal activities of the urban society, normally discarded as useless or unwanted or those that have lost their value to the first user and are a major cause of pollution (Berkun,1991; Mee and Topping, 1998). Wastes can be further classified into biodegradable and non-biodegradable waste or grouped into organic and inorganic waste. Organic waste is referred to waste that are combustible, it contain matters such as animal and vegetative matter, refuse, animal excreta, tree leaves, sticks, rags etc.

The implication is that, this class of waste can decay with time and is highly detrimental to human health and the environment. When the waste comes into contact with stagnant water it produces an irritating odour, surface and ground water are contaminated, soil contamination and air pollution. It serves as a breeding ground for insect such as mosquitoes and other dangerous insect that transmit deadly diseases. Inorganic waste referred to waste that are non-combustible, it contain matters and element such as plastics, broken glass, tiles, metals, grit etc. These matters cannot decay and therefore stay as long as they remained solid (Wright, 2004, Abd'razack at al., 2013).Open dump sites unfortunately are still the means of disposal of solid wastes in developing countries where the waste is dumped in uncontrolled manner, can be detrimental to the urban environment. Solid waste disposals (open dumps, landfills, sanitary landfills or incinerators) represent a significant source of heavy metals released into the environment (Yarlagadda, et al.1995; Waheed et al. 2010; Iwegbue et al. 2010;Bretzel and Calderisi2011; Rizo et al. 2012).Dumpsite contains different kinds and concentrations of heavy metals, depending on the age, contents and locations, in the recent times, it has been reported that heavy metals from waste dumpsites can accumulate and persist in soils at an environmentally hazardous levels (Ebong, et al., 2007).Soil contamination by heavy metals from waste disposal sites is a serious problem in industrial and urban areas (Mandal and Sengupta, 2006). Soils are regarded as the ultimate sink for heavy metals discharged into the environment, as many heavy metals are bound to soils as said by (Obiajunwa, et al. 2002).

According to the Berrow and Reaves (1984) reported that soils have become polluted if contain the amount of heavy metals that exceed the upper limit of an accepted normal range. With the extensive development of industry, many problems of soil pollution have been arises. Soil Contamination of heavy metals in the dumpsite environment is of major concern because of their toxicity and threat to human life and the entire environment (Kanmani, et al., 2013).Many of the heavy metals are toxic to organisms at low concentrations. However, some heavy metals, such as copper and zinc are also essential elements. Concentrations of essential elements in organisms are normally homeostatically controlled, with uptake from the environment regulated according to nutritional demand (Duffus, 2002).Heavy metals are non-biodegradable and undergo a global eco-biological cycle in which natural soils are the main pathways (Ukpebor et al., 2005). and the plants can accumulate these heavy metals in their tissues at concentrations greater than the ambient soil and pose a health threat to humans who consume them (Ademoroti, 1996). In the human body, the metallic toxicants attack the proteins notably the enzymes and their toxic effects are cumulative and cause slow poisoning of the system over a period of time (Nriagu, 1988; Ukpebor et al*.,* 2005). Heavy metals have been implicated in the upsurge of liver and kidney diseases, and is believed to be responsible for a high proportion of mortality caused by kidney and liver morbidity (Friberg, et al., 1986; Herber et al., 1988; Ndiokwere, 2004), pains in bones (Tsuchiya, 2018), mutagenic, carcinogenic effects (Fischer and Kazantzis, 1987, Heinrich, 1988), neurological disorders, especially in the foetus and in children which can lead to behavioral changes and impaired performance in IQ tests (Lansdown, 1986; Needleman, 1987).Soil Contamination of heavy metals in the dumpsite environment is of major concern because of their toxicity and threat to human life and the entire environment (Kanmani, et al., 2013).

AREA OF STUDY

The study was carried out at Güzelyurt dumping area, part of Northern Cyprus. Güzelyurt has the following geographical coordinates of (Latitude 35° 11′ 53″ N, 32° 59′ 38″ E) represent the northern limits of the most active part of Mediterranean Sea, Güzelyurt dumping yard is located in approximately 45 kilometers (28mi) North of Nicosia city, the capital city of Turkish Republic of Northern Cyprus. The area is among the biggest dumping site in northern Cyprus with about twenty eight (28) hectare in size, and receives the huge amount of solid wastes and some sludge waste from domestic and industrial solid waste. While color of soil at Güzelyurt dumping site (GDS) are of different types some portion is reddish, blackish, while other portion is ashes as a result of wastes burning activities at dumping area(Önet, et al.,2020).

Plate 1: Güzelyurt Dumping Site

Plate 2: Side View of thestudy Area

MATERIALS AND METHOD

The effects of waste disposal in soil samples collected at randomly selected sampling points in Güzelyurt dumping site, contaminated and uncontaminated (control) zones were sampled with an average distance of about ten to fifteen meter (10m–15m) from each point.

Table 1: Sample collection procedure indicating location and Ids number

Sample Number	Sample ID	Location	Depth	Polyethylene bags
1	G1	Point 1	20cm	A1
2	G2	Point 2	20cm	B1
3	G3	Point 3	20cm	C1
4	G4	Point 4	20cm	A2
5	G5	Point 5	20cm	B2
6	G6	Point 6	20cm	C2
7	G7	Point 7	20cm	A3
8	G8	Point 8	20cm	B3
9	G9	Point 9	20cm	C3
10	G10	Point 10	20cm	A4
11	G11	Point 11	20cm	B4
12	G12	Point 12	20cm	C4
13	G13	Point 13	20cm	A5
14	G14	Point 14	20cm	B5
15	G15	Point 15	20cm	C5
16	G16	Point 16	20cm	A6
17	G17	Point 17	20cm	B6
18	G18	Point 18	20cm	C6
19	G19	Point 19	20cm	A7
20	G20	Point 20	20cm	B7
21	G21	Point 21	20cm	C7
22	G22	Point 22	20cm	A8
23	G23	Point 23	20cm	B8
24	G24	Point 24	20cm	C8
25	G25	Point 25	20cm	A9
26	G26	Point 26	20cm	B9
27	G27	Point 27	20cm	C9
28	G28	Point 28	20cm	A10
29	G29	Point 29	20cm	B10
30	G30	Point 30	20cm	C10
31	G31	Point 31	20cm	A11
32	G32	Point 32	20cm	B11
33	G33	Point 33	20cm	C11
34	G34	Point 34	20cm	A12
35	G35	Point 35	20cm	B12
36	G36	Point 36	20cm	C12
37	G37	Point 37	20cm	A13
38	G38	Point 38	20cm	B13
39	G39	Point 39	20cm	C13
40	G40	Point 40	20cm	A14
41	G41	Point 41	20cm	B14

42	G42	Point 42	20cm	C14
43	G43	Point 43	20cm	A15
44	G44	Point 44	20cm	B15
45	G45	Point 45	20cm	C15

Soil samples were collected from the site by used of the following field equipment's such as auger (posthole auger), hammer, polythene bag, pen, paper and permanent maker for labeling soil samples and move to laboratory for soil analysis. At each sampling point soil were collected with an auger at depth of (0-20cm) and placed in polyethylene bag prior to transfer at 70^{o}c Oven in the laboratory and stored under identical condition until use. Soil sample passed through sieve pooled and homogenized in a vibratory homogenizer for soil solid samples, from each composite sample being selected for analysis.

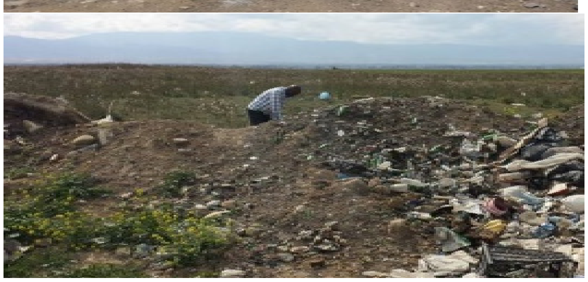

Plate 3 and 4: collection of soil samples from study area

XRF Analysis Procedures in the Laboratory

Soil samples when collected are mixed well and dried in the oven at temperature of 70^{o}c for 24hrs. It is then sieved with a 600 mesh to remove rocks, plants and other unwanted materials collected along with soil sample. Further sieved with 150 micron mesh to obtain powder for sample preparation, the powder is pressed under very high pressures (25mpa) into a tablet, when pretreatment was done, analysis were carried out to find the results of a particular soil sample.XRF is a non-destructive analytical method used to identify and determine the concentrations of elements present in samples. XRF is based on the principle that individual atoms, when excited by an external energy source, emit X-ray photons of a characteristic energy or wavelength. By counting the number of photons for each of the energy emitted from a sample, the elements present may be identified and quantified.XRF was conducted in the laboratory for the soil sample using the Rigaku ZSX primus II. This method allows the mineralogy of material to be determined by measuring the characteristics fluorescent rays of each crystalline structure features.

RESULTS AND DISCUSSION:

The elemental composition of various soil samples collected from the study area, method allows mineralogy of material to be determined by measuring characteristics fluorescent rays of each crystalline structural feature.

Table 2: Soil Samples Elemental Composition (XRF Test results in %)

Sample number	Zn	Cu	Pb	Cd
1	0.0060	0.0031	n.d	n.d
2	0.0073	0.0062	-	-
3	0.1240	0.0175	0.0056	-
4	0.0042	0.0016	-	-
5	0.0055	0.0051	-	-
6	0.0062	0.0042	-	-
7	0.1740	0.0171	0.0182	-
8	0.0078	0.0014	-	-
9	0.0077	0.0047	-	-
10	0.0065	0.0035	-	-
11	0.0245	0.0090	0.0148	-
12	0.0462	0.0592	0.0404	-
13	0.0104	0.0063	-	-
14	0.0170	0.0065	0.0033	-
15	0.0075	0.0045	-	-
16	0.0313	0.0109	0.0053	0.0186
17	0.0122	0.0085	0.0042	-
18	0.0093	0.0056	0.0049	-
19	0.0671	0.0086	0.0022	-
20	0.0071	0.0042	-	-
21	0.0115	0.0045	-	-
22	0.0189	0.0052	0.005	-
23	0.0118	0.0053	0.0015	-
24	0.0072	0.0031	0.0025	-
25	0.0158	0.0096	0.0023	-
26	0.0251	0.0055	-	-
27	0.0159	0.0064	0.0044	-
28	0.0121	0.0064	0.0041	-
29	0.0252	0.0065	0.0041	-
30	0.0112	0.0047	-	-
31	0.0153	0.0040	0.0021	-

32	0.0188	0.0070	0.0055	-
33	0.0393	0.0117	0.0082	-
34	0.0142	0.0061	0.0018	-
35	0.1584	0.0053	-	-
36	0.0056	0.00038	-	-
37	0.0688	0.0053	-	-
38	0.0259	0.0112	0.0088	-
39	0.0056	0.00038	-	-
40	0.211	0.0293	0.0105	-
41	0.0211	0.0077	0.0039	-
42	0.0252	0.0128	0.0048	-
43	0.0056	0.0047	-	-
44	0.0117	0.0064	0.0094	-
45	0.0068	0.0050	0.0043	-

* n.d= none detected

Specific Heavy Metal Converted Results:

The concentrations of the heavy metals were determined using WDXRFS by analysis of their X–ray spectral lines program and the values tabulated for the specific heavy metal element, the relation below is use for conversion of selected XRF values given in oxide forms to ppm or ppb units. The following data were use as in parameters for the calculation.

XRF values = these is the values detected from the oxide analysis by the instrument, it is multiplied by 10,000 to obtained a values that is to be used in the relation

Molecular weight of the compound is also determined as well as the atomic weight, all from the periodic table of elements, by multiplying and adding the elemental values

X = is refer to the unknown concentration in ppm

$$X\ (ppm) = \frac{\text{Atomic Weight of Particular Element } \times \text{ detected XRF values(\%)} \times 10{,}000}{\text{Molecular Weight of the Oxide of the Compound}}$$

XRF analysis of soil sample shows levels of selected heavy metals concentrations, metals concern are Zinc, Copper, Lead and Cadmium. They were detected in a hypothesized concentration and almost in all samples, except Cadmium were detected in one sample G16-A6,results of XRF-values are expressed as mass concentration i.e. mg/kg which is equivalent to ppm-values.

Table 3: Heavy metals concentration (mg/kg) in soil samples

Metals	Soil samples	*USEPA
Zinc (Zn)	1397.96	200
Copper (Cu)	472.9	52
Lead (Pb)	375.0	20.11
Cadmium (Cd)	162.8	1-3

*Maximum Permissible Limit of Metals (ppm) in Soil by USEPA
Source: USEPA (2020).

Trend of zinc (Zn) concentration in soil shows different values for zinc in the soil sampling points. Comparisons of sampling points indicate that point A is more contaminated in relation to B and C with respect to zinc, values ranging from 33.7mg/kg to 1397.96mg/kg. Shows that Concentration of zinc exceeds the allowable values according to USEPA. Soil analysis shows that all samples consist of copper (Cu), but some have high concentration of copper than others and it's in the majority of the samples. Concentration of copper in soil samples range from 11.18mg/kg to 472.9mg/kg which exceed the allowable values. Concentration of lead (Pb) in the soil samples. XRF-result shows that lead Pb concentration is low in some soil, high in some, while lead is not detected in some soil sample. Lead is detected in sampling point A, B, and C which is the contaminated points, immediate and outmost points, in other words the center, outer and outmost area, the mass concentration of lead ranges from 4.64mg/kg to 375.0mg/kg which exceed the permissible values of USEPA in soil. the cadmium concentration is only detected at particular sampling point of A6 in a centre area which is highly contaminated site of the dumpsite, concentration of cadmium is entirely high which exceeded the permissible values of all environmental organization such as USEPA, WHO and others environmental research bodies. According to Strnad, et al., (1993) high concentration of cadmium in soil, the uptake by plants increases with results in decreases of plants yields. Leaf litter decomposition is greatly reduced by heavy metal pollution and cadmium has been identified as the important causative agent for this effect. Also the toxic effects of cadmium on mammalian testis have been well established (Miller, 1991). Cadmium is virtually toxic to every system in the human body in general. Effects of acute cadmium (Cd) poisoning in human are very serious issue. Among them are high blood pressure, kidney damage, destruction of testicular tissue and red blood cells. Much of the physiological action is probably due to similarity of cadmium (Cd) to zinc (Zn), thus Cd may replace Zn in some enzymes thereby altering the stereo structure of mammals and impairing the catalytic activity. Symptoms of diseases ultimately result (Manahan, 1993). The result shows that there is significant changes in soil sample heavy metal values Zinc, copper were detected at all sample with high values and moderate values while lead and cadmium exceed the permissible values of the USEPA. Comparison of soil samples collected from the different sampling point shows that Güzelyurt dumping site has the high and abundant zinc, copper content of about 1397.96 and 472.9mg/kg as the highest values and lead with high values of about 375.0mg/kg, cadmium with 162.8mg/kg in one sample as a highly contaminated points. Generally the soils of Güzelyurt Solid waste dumping site are highly contaminated, because the heavy metals concentrations exceed the permissible or allowable levels in the soil.

CONCLUSION

The enhancement of potentially toxic metals in soils and vegetation growing in the area could lead to deleterious effects to both plants and health of those using them, the effect may occur to the biota at considerable distance from the source as a result of long distance plume dispersal or drainage from soil into some water channel. Even at relatively low level air, water and soil pollution can easily interfere with the wildlife population and natural vegetation cover, changed atmosphere and contaminate the water, and caused contamination in our homes. In addition to indicating the hazard to the grazing animals in the area, these results point out the needs to monitor heavy metals content in meat and vegetables obtained in the area and marketed for human/animal consumption. People of the area may be facing an additional increasing of toxic trace metals from cattle and other animals exposed to very high concentration of these metals. The research work present data and results obtained from the analysis of soil samples collected within the study area in northern Cyprus. Based on the conducted experiments, we may conclude large amounts of Copper (Cu), Zinc (Zn), Lead (Pb), and Cadmium (Cd) were found in Güzelyurt dumping site. These elements can be related to the wastes deposited at the site or indiscriminate deposition of used metals and the mining processes/activities that occurred in the past at the inland. Seasonal changes affect some elements in soil content at different locations. `From this study it is clear that contamination of the environment by the industrial and domestic wastes disposal has occurred, and continues to occur in Güzelyurt dumping site. However it is important and necessary to have more extensive study on heavy metal contamination to establish the extent of pollution by the industries in all other environments.

RECOMMENDATIONS:

Since the industries plays a very vital role in the development of economy in both rural and urban areas as well as that of entire country, it would be very important if the following proposed actions are taken to protect the lives and properties of people depend on natural environmental resources such as crops around and using resources for their livelihood.

1. In order to prevent the impacts of the heavy metals to the livestock and people living around the dumping site, the dump site should be fence the sedimentation points and reduce the level of the elements in the contaminated site and also used of dumpsite as manure should be stopped to prevent possible transfer of toxic metals into the food chain
2. For the future study should be carried out in different seasonal conditions, such as dry and raining season's which will make the comparison in terms of heavy metals concentration in dumping site soil, because seasonal changes effect that elements in soil content at different locations.
3. To preserve the unpolluted state of the dumping site and environs, it remains important that wastes disposal from the industrial and domestic sources or the catchment area are devoid of heavy metals and regulatory mechanism should be enforced to ensure that current trends are not exacerbated
4. The manufacturing industries should perform continuous liming of the industry effluents and the farmers in the surrounding communities should be encouraged to apply the cattle manure on their farms since this helps in reducing the bioavailability of the heavy metals and increases the yield of plants grown in polluted soils.
5. Advance dust reduction facilities should be installed in the industries, dumping site and periodic spraying of the roads around the dump site with water, especially during the dry season should be done to reduce the health problems caused by burning of wastes or dust laced with heavy metals at the dumping site.
6. Plants such as vetiver grass (vetiveriazizanioides) should be introduced in the sedimentation points, surrounding farms and long effluent channels to absorb the heavy metals. Finely ground roots of plants could be installed at the soil sample discharge points to act as heavy metals filter and reduce the levels of these elements, the steam and

leaves of the plants can be used as manure, paper, making ropes, fibre and biogas production materials.

7. Extensive periodic internal and external environmental survey should be carried out by both the industrial and other organization such as USEPA, WHO, NEMA and other environmental research institutions to help in preventing any excessive discharge of harmful effluents/wastes which has not been traced to the required standards.
8. Advanced methods need to be used for determination of heavy metals in animals, urine and human blood; further research should be done to identify the nature of elements.
9. Serve as a guideline for future researchers and environmental managers to identify future anthropogenic impacts at the study area with respect to the metals, and better assess the need for remediation by monitoring for changes from the existing levels, can also be useful for the management and sustainable development in our environment.

ACKNOWLEDGEMENT

I acknowledge input and assistance of our research supervisors and entire North Cyprus Environmental protection agencies in preparing our environmental scientific research paper.

REFERENCES

Abd'razack, Nelson T. A. et al., (2013). An Appraisal of Solid Waste Generation and Management in Jalingo City, Nigeria: journal of Environmental and Earth science, vol. 3, No. 9, 2013 ISSN 2225-0948.

Ademoroti, C.M.A., (1996). Environmental Chemistry and Toxicology: Foludex Press Ltd. Ibadan, p. 215.

Agbu, Y., **Abdul'razack, N. Utange, J, Z** (2013). An appraisal of solid waste generation and management in Jalingo city Nigeria Journal of environmental and Earth science Vol 3, No 9.pages: 21-22

Alloway, B.J. and Ayres, D.C.,(1998). Chemical Principles of Environmental Pollution: Blackie Academic & Professional. London. Pp 204-218.

Berrow, M.L. and Reaves, G.A., (1984). Background Levels of Trace Elements in Soils, International Conference, London, July (1984).

Berkun, M.,(1991). Solid Waste Characteristic and Removal Planning in the Eastern Black Sea Region: research projects no. 91112001, Karadeniz Technical University, Trabzon, Turkey

Bretzel, F.C, Calderisi, M.,(2011). Contribution of a municipal solid waste incinerator to the trace metals in the surrounding soil. Environ Monit Assess 182:523–533

Duffus, J. H., (2002), "Heavy Metals" – A meaningless term. Pure and Applied Chemistry 74, 793-807.

Ebong, G.A. et al,(2007). Heavy Metals Accumulation by Talinum. Triangulare Grown on waste Dumpsites in Uyo Metropolis Akwa Ibom State, Nigeria. J. Appl.Sci.**7 (10),** 1404 –1409.

Fischer, A.B.,(1987). Mutagenic effects of cadmium alone and in combination with antimutagenic selenite: Proc. 6th Int. Conf. on Heavy Metals in the Environment, New Orleans Volume two (2), CEP Consultants Ltd, Edinburgh.112-114.

Friberg, L., et al., (1986). In: (eds.) Handbook on the Toxicology of Metals, Volume 11. Elsevier, Amsterdam. New York, Oxford.130-184

Gadzała-Kopciuch, R. et al., (2004). Some Considerations about Bioindicators in Environmental Monitoring: In Polish Journal of Environmental Studies. Vol. 13, No. 5 (2004), 453-462

Heinrich, U.,(1988). Carcinogenicity of cadmium: Environmental Toxins, Volume 2, Cadmium. (Vol. eds.: Stoeppler M and Piscator M). Springer, Berlin-Heidelberg, New York-London-Paris-Tokyo.13-15

Herber, F.R.M. et al,(1988).A kinetics and kidney effects of Cadmium: Environmental Toxins, Volume 2, Cadmium. (Vol. eds.: Stoeppler M and Piscator M). Springer, Berlin-Heidelberg, New York-London-Paris-Tokyo.115- 133

Iwegbue, C.M.A. et al, (2010). Determination of trace metal concentrations in soil profiles of municipal waste dumps in Nigeria. Environ Geochem Health 32:415–430

Kanmani, S., et al.,(2013). Assessment of heavy metal contamination in soil due to leachate migration from an open dumping site: App water sci. 3:193-205 published at springerlink.com

Kazantzis, G., (1987). The Mutagenic and Carcinogenic Effect of Cadmium: An-update, Journal of Toxicology and Environmental Chemistry, 15 83-100.

Lansdown, R., (1986). Lead, intelligence attainment and behavior. In: Lansdown, R. and Yule, W. (eds.) the Lead Debate, Croom Helm London-Sydney, 235-270.

Manahan, S. T. (1993). Fundamentals of Environmental Chemistry: Lewis Publishers. U.S.A. Pp 380 - 420

Mandal, A., Sengupta, D.,(2006). An assessment of soil contamination due to heavy metals around a coal- fired thermal power plant in India. Environ Geol 51:409–420

Mee, D.L, Topping G.,(1998). Black Sea Pollution Assessment; In: GEF Black Sea environmental programme. Black Sea environmental series, p 10

Miller, G. T., (1991). Environmental Science Sustaining the World: Third edition, wards worth publishing company. Belmont. Pp. 12 – 20.

Ndiokwere, C.L., (2004). Chemistry and Environment: University of Benin, Inaugural Lecture Series, p. 73

Needleman, H.L., (1987). Low level lead exposure and children's intelligence: A quantitative and critical review of modern studies, Proc. 6th Int. Conf. on Heavy Metals in the Environment, New Orleans, Volume 1. CEP Consultants Ltd., Edinburg. 1-8

Nriagu, J. O., (1988). Copper in the Environmental part 2: Health effects, Wiley Interscience Publication, New York. P. 285 – 306.

Obiajunwa, E.I, et al.,(2002). Characterisation of Heavy metal Pollutants of Soils and Sediments around a Crude Oil Production Terminal Using EDXRF: NuclInstrum Methods Phys Bull 194:61–64.

Önet, S.,(2020). Solid Waste Management System record in Northern part of Cyprus, (personal interview).

Rachel, O.A. et al, (2009): Municipal Solid Waste Management in Developed and Developing Countries: Japan and Nigeria as case studies, Solid Waste Audit Report. Federal Capital Territory, Abuja Nigeria

Rizo, O.D. et al, (2012). Assessment of metal pollution in soils from a former Havana (Cuba) solid waste open dump: Bull Environ Contam. Texaco, 88:182–186.

Strange, K.,(2002). Overview of waste management options: their Efficacy and acceptability, Royal society of chemistry.

Strnad, V. Zolotareva, et al,(1993). Effects of lead, cadmium and copper contents in the soil on their Accumulation in crops and yields: Rosh Vyroba 1990, 36(14) 411 – 17(Czech), CA 114(3) 23011r.

Tsuchiya, K. (2018). Cadmium Studies in Japan 5th Review Kodansha Ltd. Tokyo- Elsevier/North Holland Biomedical Press, Amsterdam-New York- Oxford.

Ukpebor, J.E, et al, (2005). The uses of heavy metals load as an indicator of the suitability of Ikpoba River for domestic and consumption purposes. Chem. Tech. J. 1: 108-115.

USEPA (2021). United state environmental protection agency; Environmental guidelines and standards. https://www.occeweb.com/og/metals-limits.pdf

Waheed, S. et al,(2010). Assessing soil pollution from a municipal waste dump in Islamabad: Pakistan, A study by INAA and AAS, J Radioanal NuclChem 285:723–732.

Wright, R.T. (2004): Environmental Science: Toward a Sustainable Future. (9th ed). Printed in the United State of America

Yarlagadda P.S. et al, (1995) Characteristics of Heavy Metals in Contaminated Soils J Environ Eng 121(4):276–286.